A Web-based Watershed Planning Tool Aimed at Reducing Soil Erosion, Sedimentation and Pollutant Loadings to the Great Lakes

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May 21st, 2008

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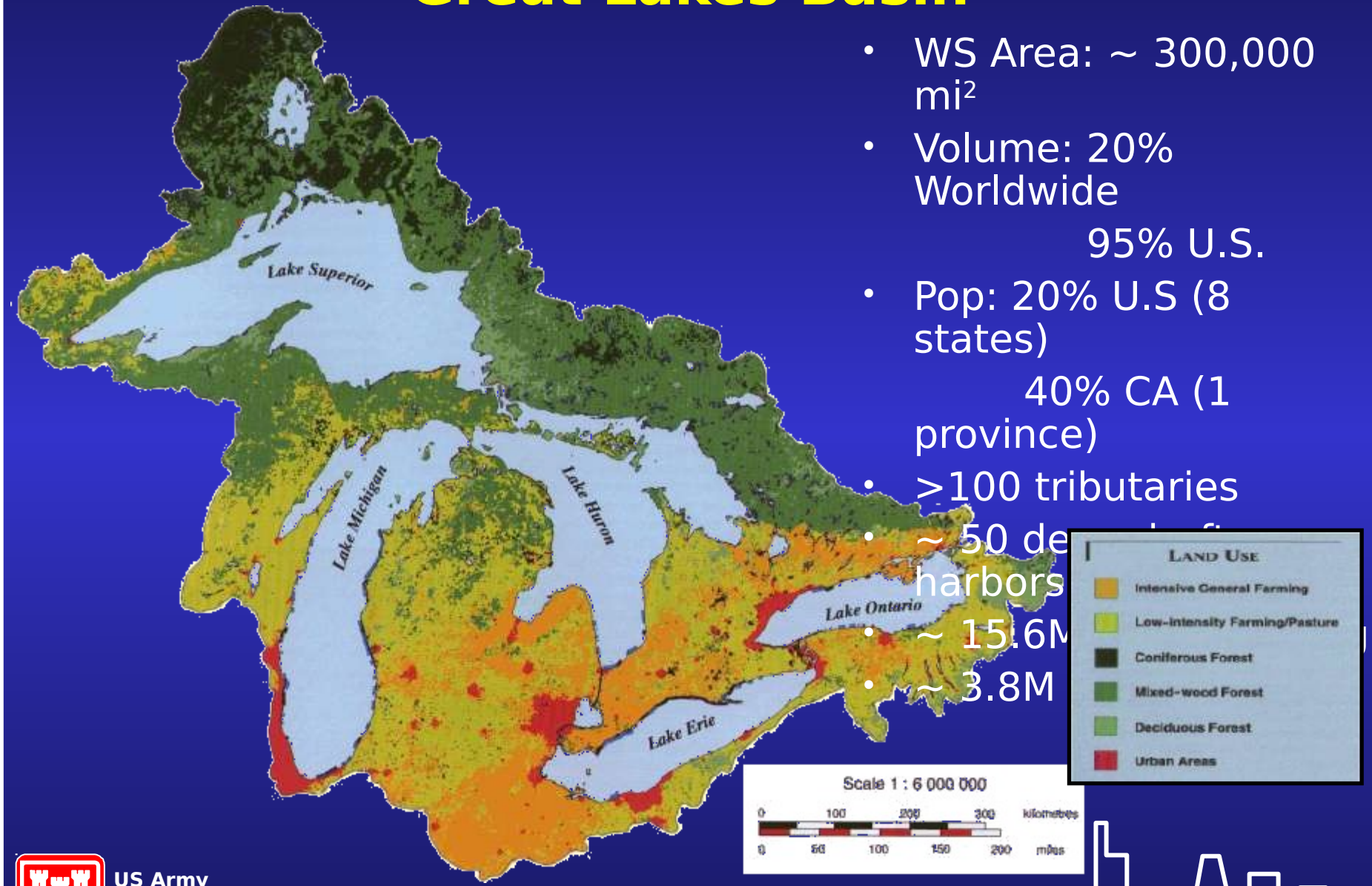
Great Lakes Basin



- WS Area: ~ 300,000 mi^2
- Volume: 20% Worldwide
  95% U.S.
- Pop: 20% U.S (8 states)
  40% CA (1 province)
- >100 tributaries
- ~ 50 de… harbors
- ~ 15.6M
- ~ 3.8M

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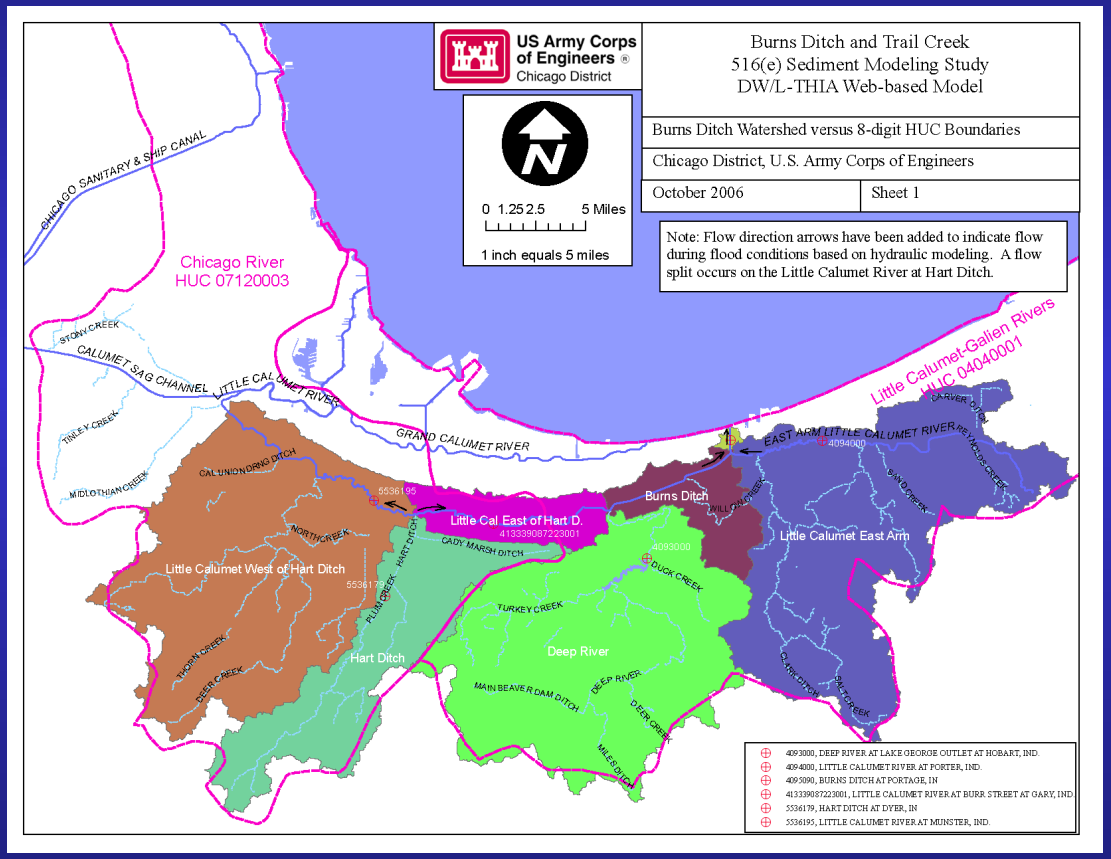
Great Lakes Tributary Modeling Program

- Authority: Sect 516(e) WRDA 96 (as amended)
- Purpose: Develop sediment delivery/transport models for GL watersheds that drain to Fed channels or AOCs
- Goal: Reduce sediment/pollutant loads = reduced Fed costs to dredge/cleanup:
  - "Grass-roots" level initiative
  - Tailored tools (based on needs & users expertise)
  - Universal/non-proprietary tools
- Approach: 3 phases, typically 3 years per trib
  - Scoping: compile data, assemble WS team, select tool
  - Model Development: varies by WS, (OTS vs. custom)
  - Tech Transfer: training workshop, manuals, follow-

Burns Ditch & Trail Creek Watersheds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Burns Ditch and Trail Creek
516(e) Sediment Modeling Study
DW/L-THIA Web-based Model
Burns Ditch Watershed versus 8-digit HUC Boundaries
Chicago District, U.S. Army Corps of Engineers
October 2006
Sheet 1
0 1.25 2.5 5 Miles
1 inch equals 5 miles
Note: Flow direction arrows have been added to indicate flow during flood conditions based on hydraulic modeling. A flow split occurs on the Little Calumet River at Hart Ditch.
Chicago River
HUC 07120003
Little Calumet-Galien Rivers
HUC 04040001
CHICAGO SANITARY & SHIP CANAL
STONY CREEK
CALUMET SAG CHANNEL
LITTLE CALUMET RIVER
TINLEY CREEK
MIDLOTHIAN CREEK
CAL UNION DRNG DITCH
GRAND CALUMET RIVER
EAST ARM LITTLE CALUMET RIVER
CARVER DITCH
SAW MILL CREEK
Burns Ditch
Little Cal East of Hart D.
Little Calumet East Arm
Little Calumet West of Hart Ditch
NORTH CREEK
HART DITCH
CADY MARSH DITCH
PLUM CREEK
THORN CREEK
DEER CREEK
Hart Ditch
DUCK CREEK
TURKEY CREEK
Deep River
MAIN BEAVER DAM DITCH
DEEP RIVER
DEER CREEK
MILES DITCH
CLARK DITCH
SALT CREEK
4093000, DEEP RIVER AT LAKE GEORGE OUTLET AT HOBART, IND.
4094000, LITTLE CALUMET RIVER AT PORTER, IND.
4095090, BURNS DITCH AT PORTAGE, IN
413339087223001, LITTLE CALUMET RIVER AT BURR STREET AT GARY, IND
5536179, HART DITCH AT DYER, IN
5536195, LITTLE CALUMET RIVER AT MUNSTER, IND.

Burns Ditch WS:

- 331 mi² / Lake Michigan
- Burns Wtwy/Harbor (Fed)
- Ag → Urban Landuse

Train Creek WS:

- 59 mi² / Lake Michigan
- Mich. City Harbor (Fed)
- Ag Landuse

Issues:

- Agricultural loadings
- Developing watersheds
- Prioritize BMPs

Burns Ditch & Trail Creek Collaborative Watershed Study Team

- NW Indiana Regional Planning Commission
- Indiana Dept. of Natural Resources
- Indiana Dept. of Environmental Manager
- Indiana Association of SWCDs
- USEPA Region V
- USFWS
- USDA – NRCS
- National Park Service
- USGS
- USACE – Chicago District
- Save the Dunes Council
- Great Lakes Commission

Burns Ditch & Trail Creek Watershed Management System

Modeling Approach:

- Add functionality to two existing planning tools:
  - Area resource planners familiar w/ DW & L-THIA models
  - Both were web-GIS based w/ unique qualities
  - Easily updatable over time w/ newer data
- Contracted with Purdue and Michigan State Universities
  - MIPR through USGS State Water Resources Research Institute Program (http://water.usgs.gov/wrri/institutes.html)

Agricultural and Biological Engineering
Purdue University
(https://engineering.purdue.edu/ABE/)

Institute of Water Research
Michigan State University
(http://www.iwr.msu.edu/)

Total Cost = $120,000 + USGS fees

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Burns Ditch & Trail Creek Watershed Management System

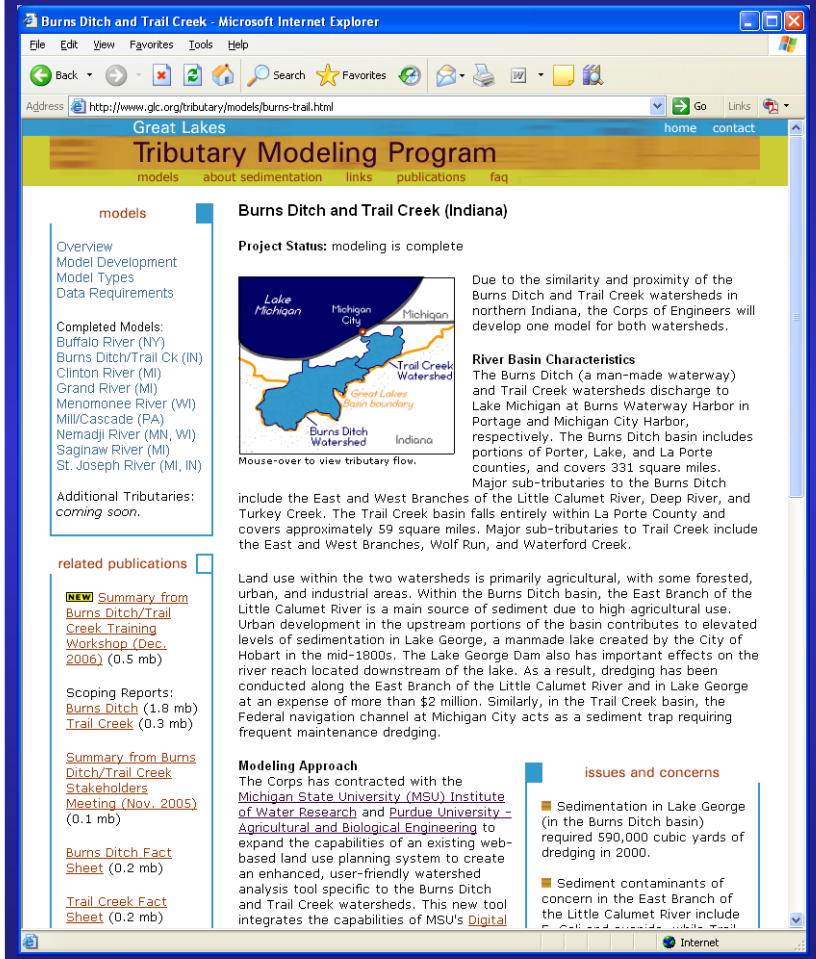
Major Tasks Accomplished:

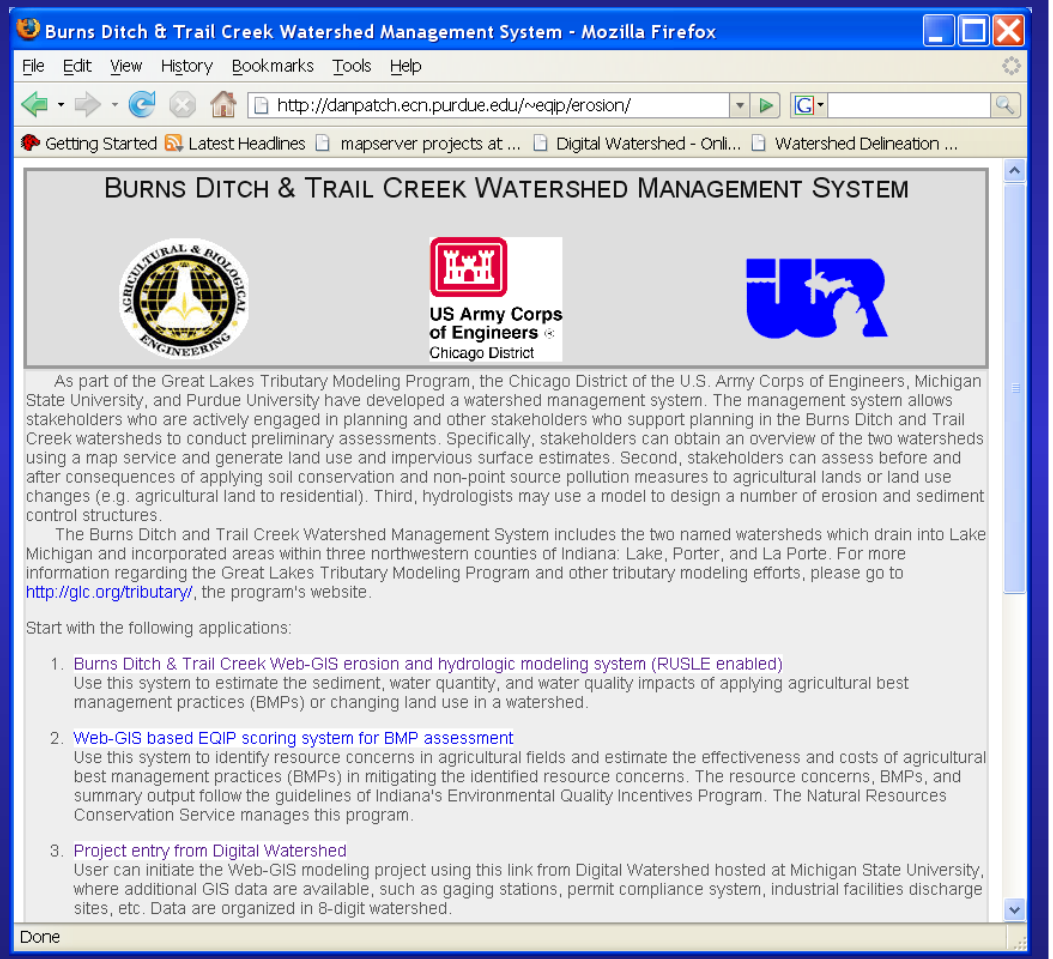
- Update data from available sources (landuse, topo, etc.)
- Interconnect web-models (pass data & results)
  - Digital Watershed (DW)
  - Long-Term Hydrologic Impact Assessment (L-THIA)
- Update sediment delivery rates using SWAT-based MUSLE
- Create new interface for Burns Ditch / Trail Creek
- Add additional non-agricultural BMPs
- Create video tutorials, exercises and documentation
- Conduct hands-on training workshop
- Revising based on feedback from users
- Currently adding Low Impact Development (LID)

Program Website & Main User Entry Point

www.glc.org/tributary/models/burns-trail.html

http://danpatch.ecn.purdue.edu/~eqip/erosion/


Burns Ditch and Trail Creek - Microsoft Internet Explorer
Great Lakes
Tributary Modeling Program
models
about sedimentation
links
publications
faq
Burns Ditch and Trail Creek (Indiana)
Project Status: modeling is complete
Lake Michigan
Michigan City
Trail Creek Watershed
Great Lakes Basin boundary
Burns Ditch Watershed
Indiana
Mouse-over to view tributary flow.
Due to the similarity and proximity of the Burns Ditch and Trail Creek watersheds in northern Indiana, the Corps of Engineers will develop one model for both watersheds.
River Basin Characteristics
The Burns Ditch (a man-made waterway) and Trail Creek watersheds discharge to Lake Michigan at Burns Waterway Harbor in Portage and Michigan City Harbor, respectively. The Burns Ditch basin includes portions of Porter, Lake, and La Porte counties, and covers 331 square miles. Major sub-tributaries to the Burns Ditch include the East and West Branches of the Little Calumet River, Deep River, and Turkey Creek. The Trail Creek basin falls entirely within La Porte County and covers approximately 59 square miles. Major sub-tributaries to Trail Creek include the East and West Branches, Wolf Run, and Waterford Creek.
Land use within the two watersheds is primarily agricultural, with some forested, urban, and industrial areas. Within the Burns Ditch basin, the East Branch of the Little Calumet River is a main source of sediment due to high agricultural use. Urban development in the upstream portions of the basin contributes to elevated levels of sedimentation in Lake George, a manmade lake created by the City of Hobart in the mid-1800s. The Lake George Dam also has important effects on the river reach located downstream of the lake. As a result, dredging has been conducted along the East Branch of the Little Calumet River and in Lake George at an expense of more than $2 million. Similarly, in the Trail Creek basin, the Federal navigation channel at Michigan City acts as a sediment trap requiring frequent maintenance dredging.
Modeling Approach
The Corps has contracted with the Michigan State University (MSU) Institute of Water Research and Purdue University - Agricultural and Biological Engineering to expand the capabilities of an existing web-based land use planning system to create an enhanced, user-friendly watershed analysis tool specific to the Burns Ditch and Trail Creek watersheds. This new tool integrates the capabilities of MSU's Digital
models
Overview
Model Development
Model Types
Data Requirements
Completed Models:
Buffalo River (NY)
Burns Ditch/Trail Ck (IN)
Clinton River (MI)
Grand River (MI)
Menomonee River (WI)
Mill/Cascade (PA)
Nemadji River (MN, WI)
Saginaw River (MI)
St. Joseph River (MI, IN)
Additional Tributaries:
coming soon.
related publications
NEW Summary from Burns Ditch/Trail Creek Training Workshop (Dec. 2006) (0.5 mb)
Scoping Reports:
Burns Ditch (1.8 mb)
Trail Creek (0.3 mb)
Summary from Burns Ditch/Trail Creek Stakeholders Meeting (Nov. 2005) (0.1 mb)
Burns Ditch Fact Sheet (0.2 mb)
Trail Creek Fact Sheet (0.2 mb)
issues and concerns
Sedimentation in Lake George (in the Burns Ditch basin) required 590,000 cubic yards of dredging in 2000.
Sediment contaminants of concern in the East Branch of the Little Calumet River include


Burns Ditch & Trail Creek Watershed Management System - Mozilla Firefox
http://danpatch.ecn.purdue.edu/~eqip/erosion/
BURNS DITCH & TRAIL CREEK WATERSHED MANAGEMENT SYSTEM
US Army Corps of Engineers
Chicago District
As part of the Great Lakes Tributary Modeling Program, the Chicago District of the U.S. Army Corps of Engineers, Michigan State University, and Purdue University have developed a watershed management system. The management system allows stakeholders who are actively engaged in planning and other stakeholders who support planning in the Burns Ditch and Trail Creek watersheds to conduct preliminary assessments. Specifically, stakeholders can obtain an overview of the two watersheds using a map service and generate land use and impervious surface estimates. Second, stakeholders can assess before and after consequences of applying soil conservation and non-point source pollution measures to agricultural lands or land use changes (e.g. agricultural land to residential). Third, hydrologists may use a model to design a number of erosion and sediment control structures.
The Burns Ditch and Trail Creek Watershed Management System includes the two named watersheds which drain into Lake Michigan and incorporated areas within three northwestern counties of Indiana: Lake, Porter, and La Porte. For more information regarding the Great Lakes Tributary Modeling Program and other tributary modeling efforts, please go to http://glc.org/tributary/, the program's website.
Start with the following applications:
1. Burns Ditch & Trail Creek Web-GIS erosion and hydrologic modeling system (RUSLE enabled)
Use this system to estimate the sediment, water quantity, and water quality impacts of applying agricultural best management practices (BMPs) or changing land use in a watershed.
2. Web-GIS based EQIP scoring system for BMP assessment
Use this system to identify resource concerns in agricultural fields and estimate the effectiveness and costs of agricultural best management practices (BMPs) in mitigating the identified resource concerns. The resource concerns, BMPs, and summary output follow the guidelines of Indiana's Environmental Quality Incentives Program. The Natural Resources Conservation Service manages this program.
3. Project entry from Digital Watershed
User can initiate the Web-GIS modeling project using this link from Digital Watershed hosted at Michigan State University, where additional GIS data are available, such as gaging stations, permit compliance system, industrial facilities discharge sites, etc. Data are organized in 8-digit watershed.
Done

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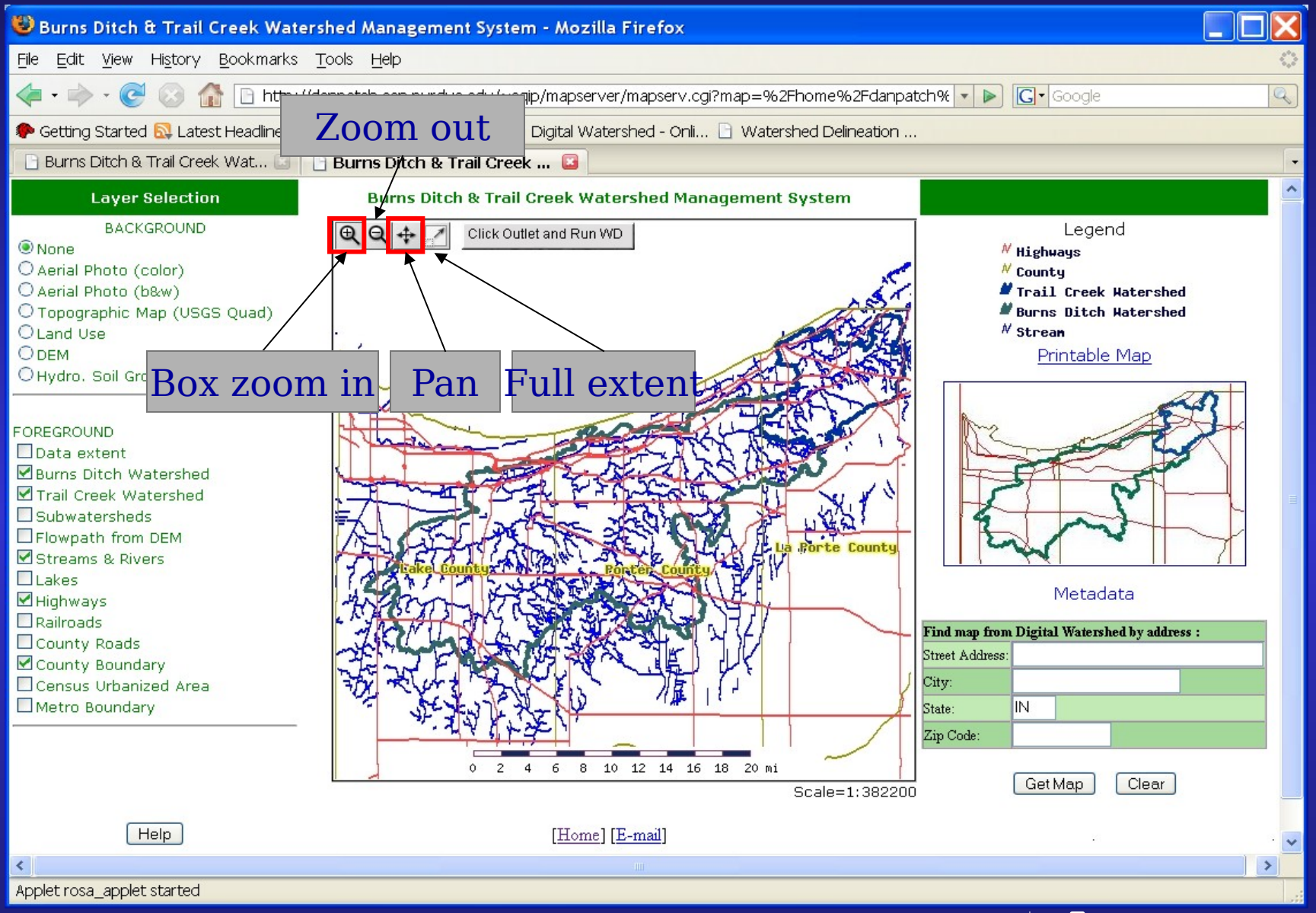

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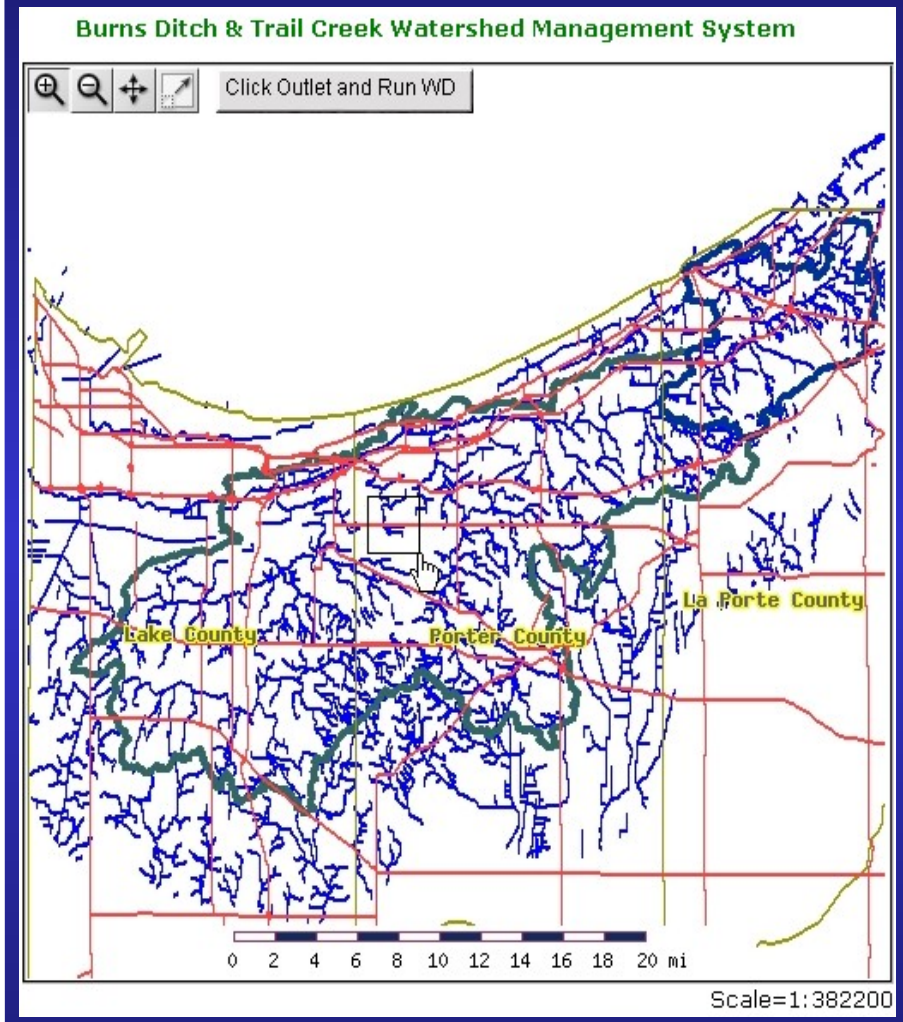
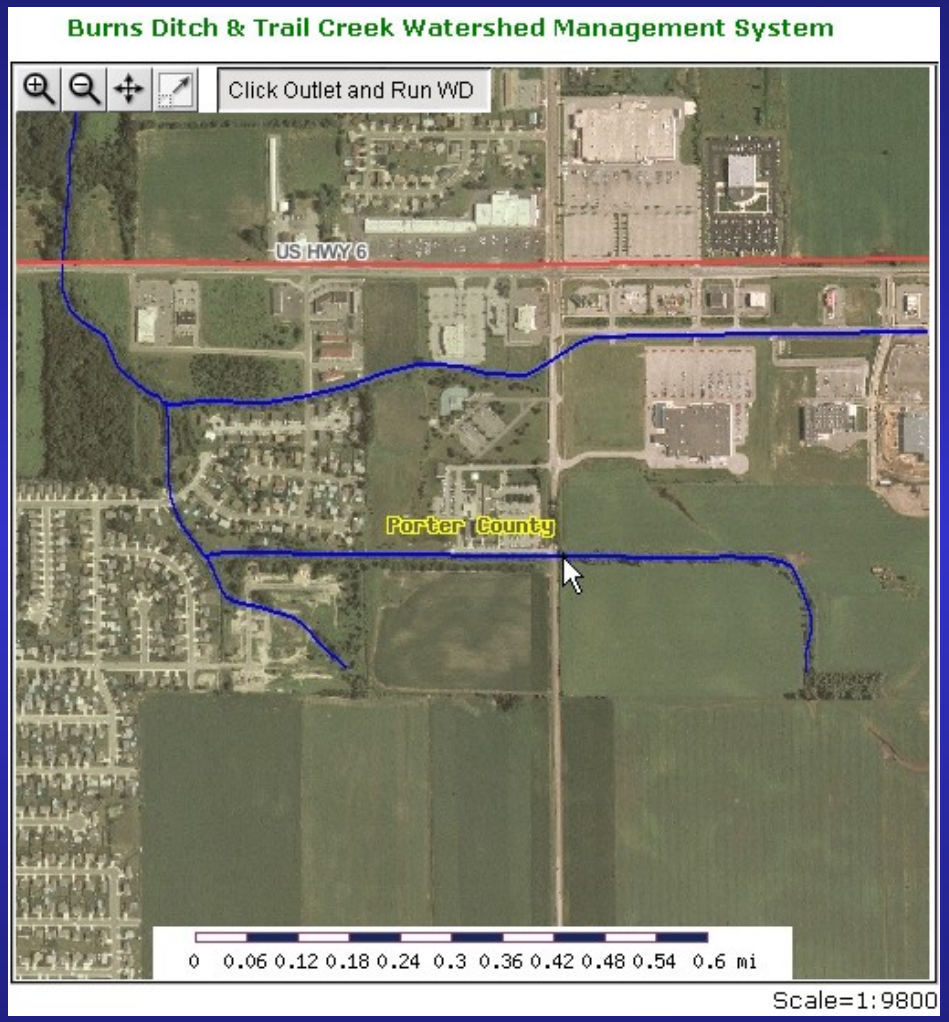
Find stream and delineate watershed...


Burns Ditch & Trail Creek Watershed Management System
Click Outlet and Run WD
Lake County
Porter County
La Porte County
0 2 4 6 8 10 12 14 16 18 20 mi
Scale=1:382200


Burns Ditch & Trail Creek Watershed Management System
Click Outlet and Run WD
US HWY 6
Porter County
0 0.06 0.12 0.18 0.24 0.3 0.36 0.42 0.48 0.54 0.6 mi
Scale=1:9800

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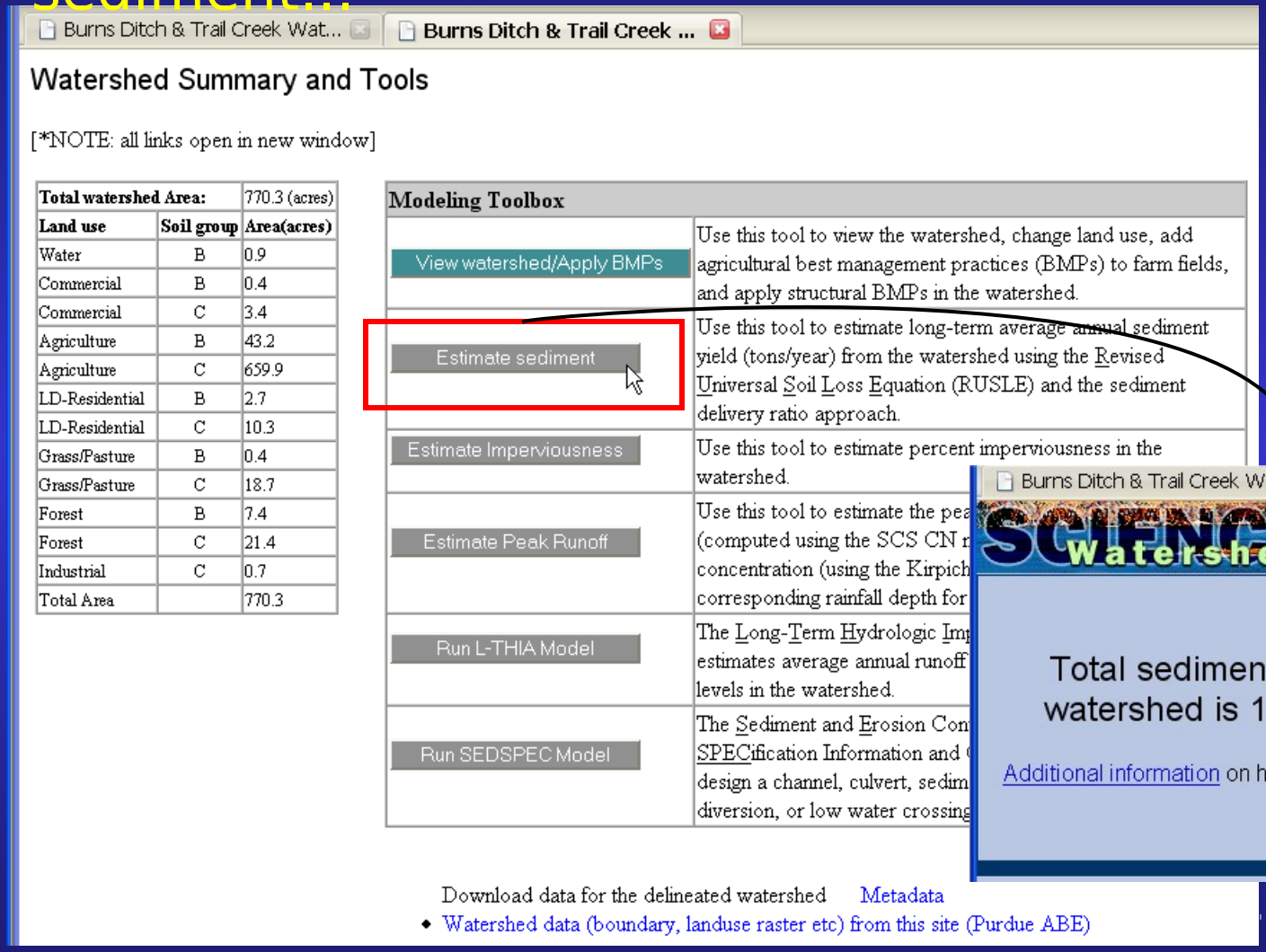
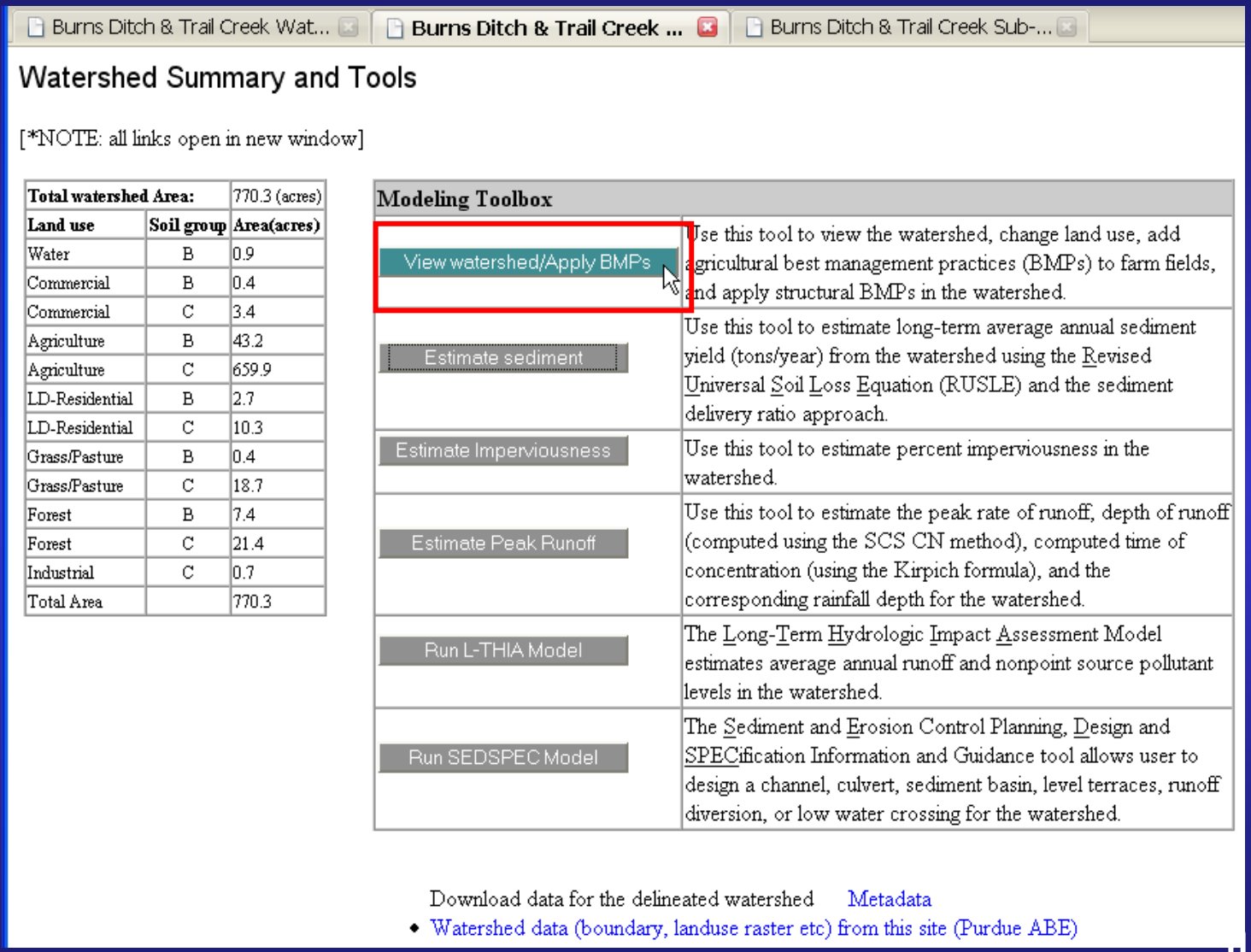
Review watershed data and estimate current sediment…


Burns Ditch & Trail Creek Wat...
Burns Ditch & Trail Creek ...
Watershed Summary and Tools
[*NOTE: all links open in new window]
Total watershed Area: 770.3 (acres)
Land use | Soil group | Area(acres)
Water | B | 0.9
Commercial | B | 0.4
Commercial | C | 3.4
Agriculture | B | 43.2
Agriculture | C | 659.9
LD-Residential | B | 2.7
LD-Residential | C | 10.3
Grass/Pasture | B | 0.4
Grass/Pasture | C | 18.7
Forest | B | 7.4
Forest | C | 21.4
Industrial | C | 0.7
Total Area | | 770.3
Modeling Toolbox
View watershed/Apply BMPs
Use this tool to view the watershed, change land use, add agricultural best management practices (BMPs) to farm fields, and apply structural BMPs in the watershed.
Estimate sediment
Use this tool to estimate long-term average annual sediment yield (tons/year) from the watershed using the Revised Universal Soil Loss Equation (RUSLE) and the sediment delivery ratio approach.
Estimate Imperviousness
Use this tool to estimate percent imperviousness in the watershed.
Estimate Peak Runoff
Run L-THIA Model
Run SEDSPEC Model
Download data for the delineated watershed Metadata
Watershed data (boundary, landuse raster etc) from this site (Purdue ABE)
Burns Ditch & Trail Creek Wat...
Burns Ditch & Trail Creek wat
SCIENCE-BASED
Watershed Management
Total sediment estimated for this watershed is 148.6 tons per year.
Additional information on how total sediment was estimated.

Review watershed and apply BMPs…


Burns Ditch & Trail Creek Wat...
Burns Ditch & Trail Creek ...
Burns Ditch & Trail Creek Sub-...
Watershed Summary and Tools
[*NOTE: all links open in new window]
Total watershed Area: 770.3 (acres)
Land use | Soil group | Area(acres)
Water | B | 0.9
Commercial | B | 0.4
Commercial | C | 3.4
Agriculture | B | 43.2
Agriculture | C | 659.9
LD-Residential | B | 2.7
LD-Residential | C | 10.3
Grass/Pasture | B | 0.4
Grass/Pasture | C | 18.7
Forest | B | 7.4
Forest | C | 21.4
Industrial | C | 0.7
Total Area | | 770.3
Modeling Toolbox
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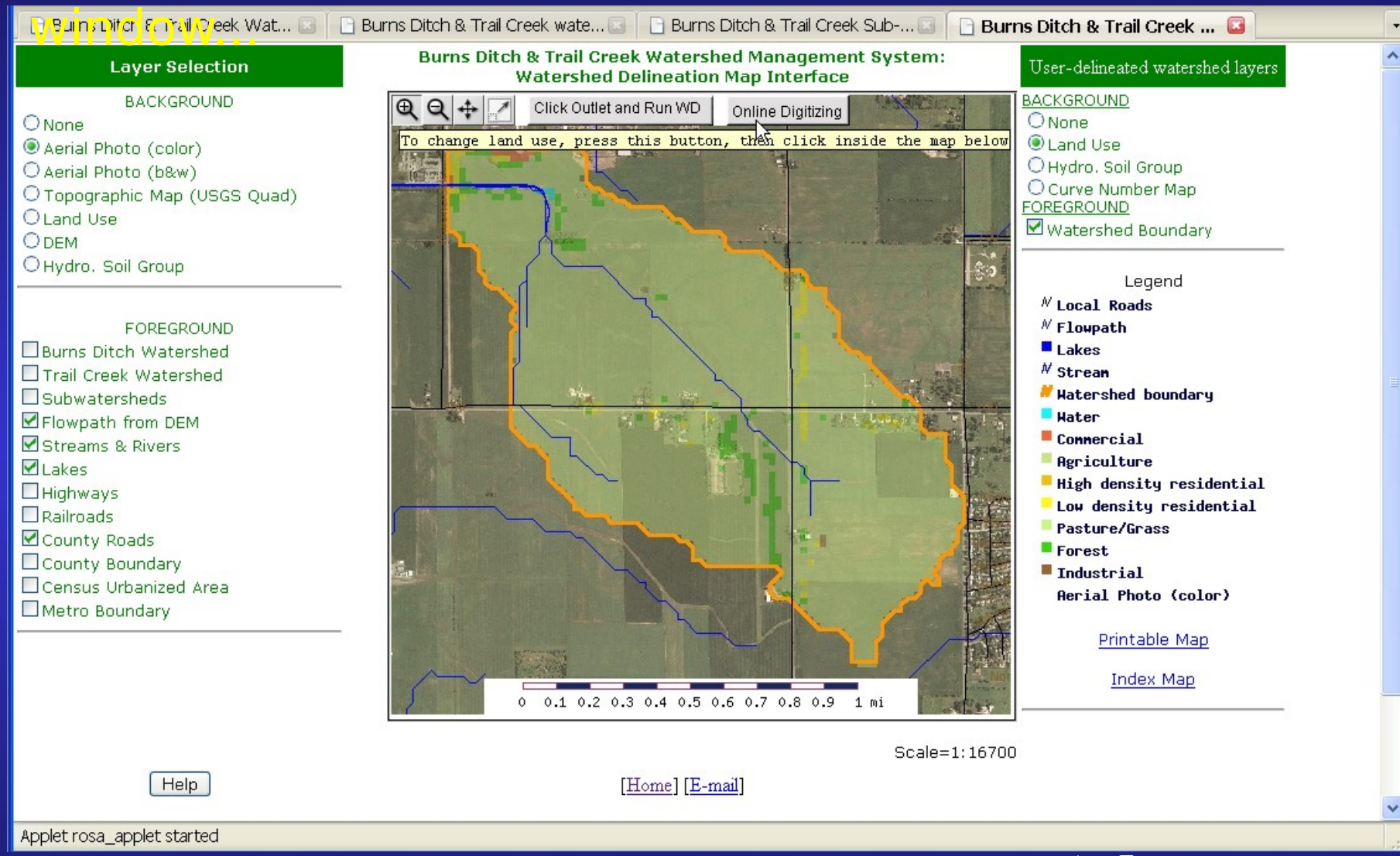
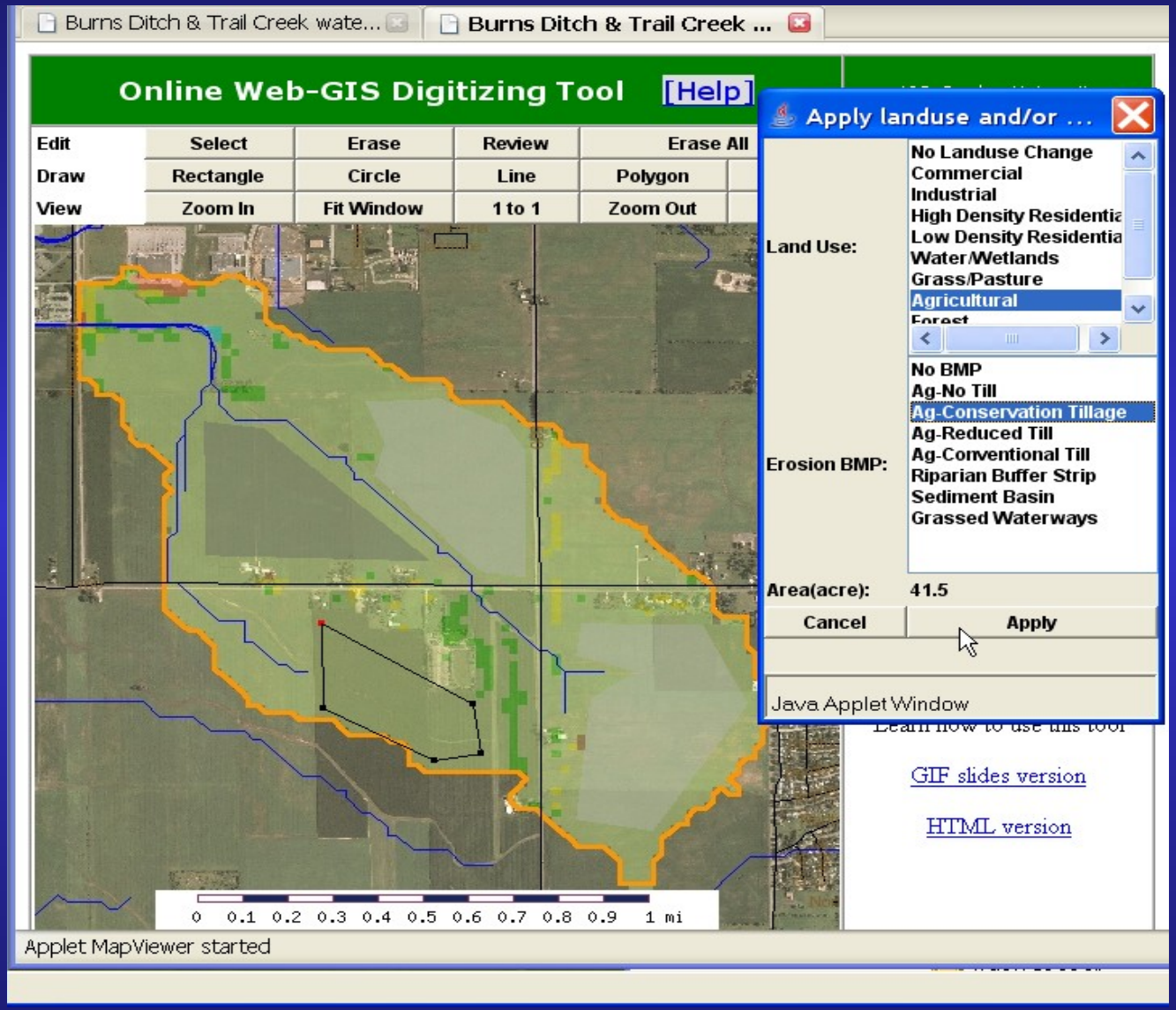
Use this tool to view the watershed, change land use, add agricultural best management practices (BMPs) to farm fields, and apply structural BMPs in the watershed.
Estimate sediment
Use this tool to estimate long-term average annual sediment yield (tons/year) from the watershed using the Revised Universal Soil Loss Equation (RUSLE) and the sediment delivery ratio approach.
Estimate Imperviousness
Use this tool to estimate percent imperviousness in the watershed.
Estimate Peak Runoff
Use this tool to estimate the peak rate of runoff, depth of runoff (computed using the SCS CN method), computed time of concentration (using the Kirpich formula), and the corresponding rainfall depth for the watershed.
Run L-THIA Model
The Long-Term Hydrologic Impact Assessment Model estimates average annual runoff and nonpoint source pollutant levels in the watershed.
Run SEDSPEC Model
The Sediment and Erosion Control Planning, Design and SPECification Information and Guidance tool allows user to design a channel, culvert, sediment basin, level terraces, runoff diversion, or low water crossing for the watershed.
Download data for the delineated watershed
Metadata
Watershed data (boundary, landuse raster etc) from this site (Purdue ABE)

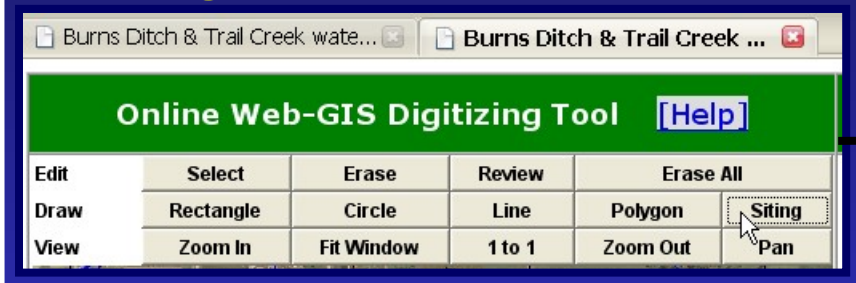
Review watershed and activate online digitizing window...

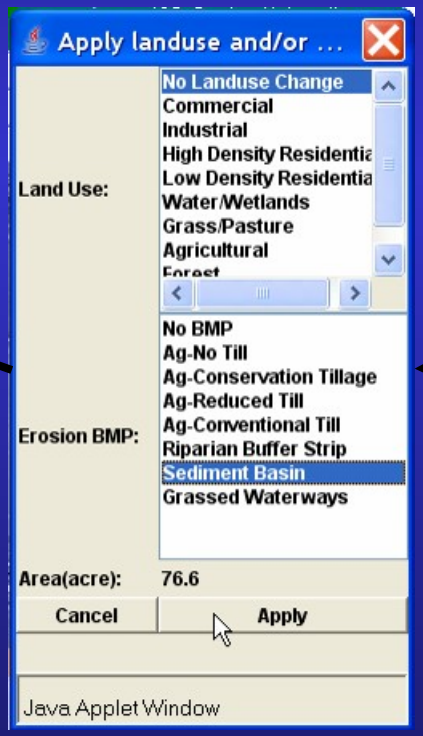


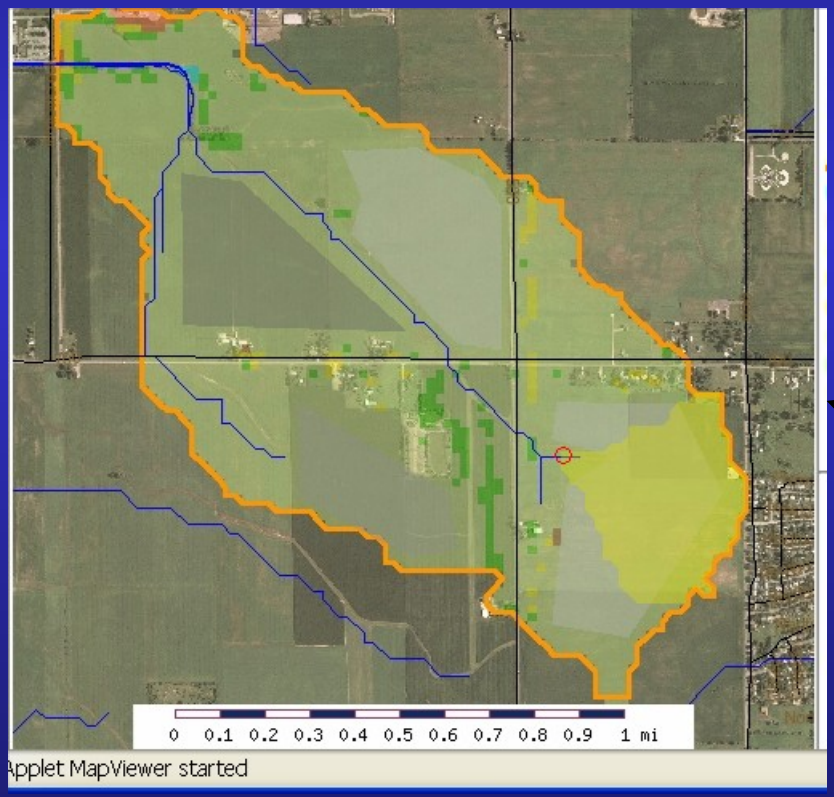
Use the online digitizing tool to apply ag-BMPs...



Use the online digitizing tool to apply structural BMPs...







Sediment Basin

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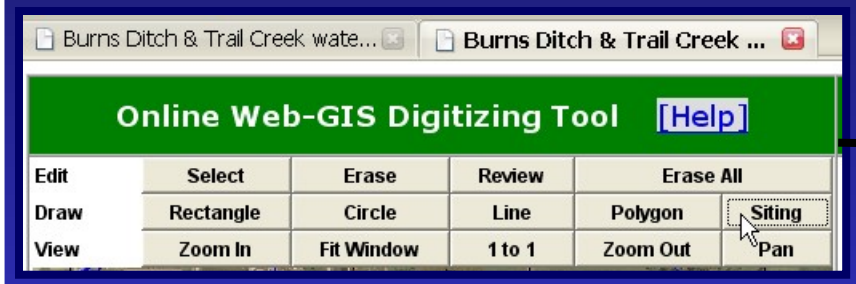
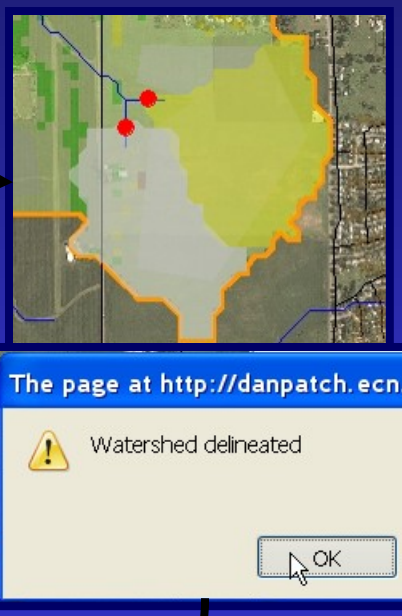
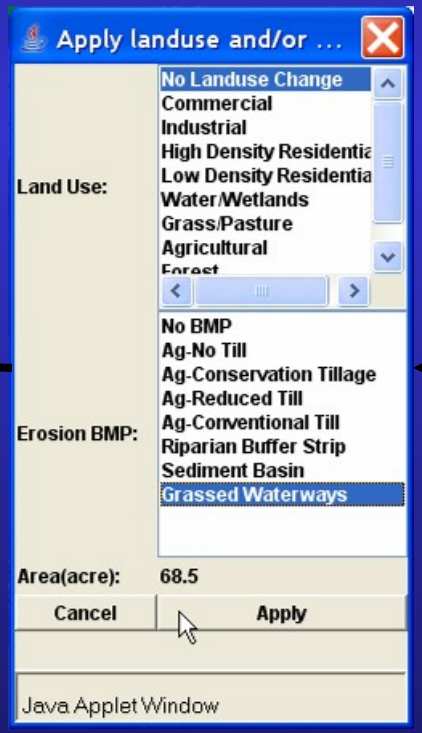
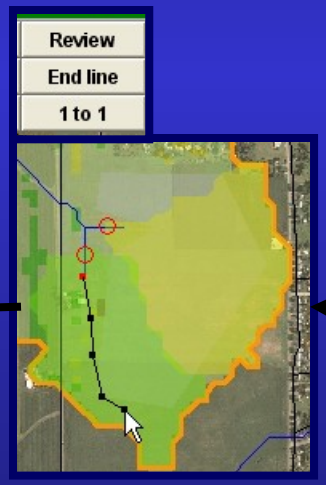
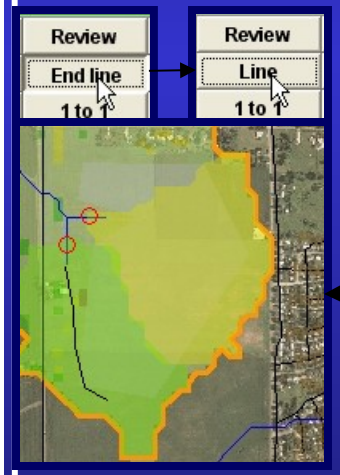
Use the online digitizing tool to apply structural BMPs...











Grassed Waterway

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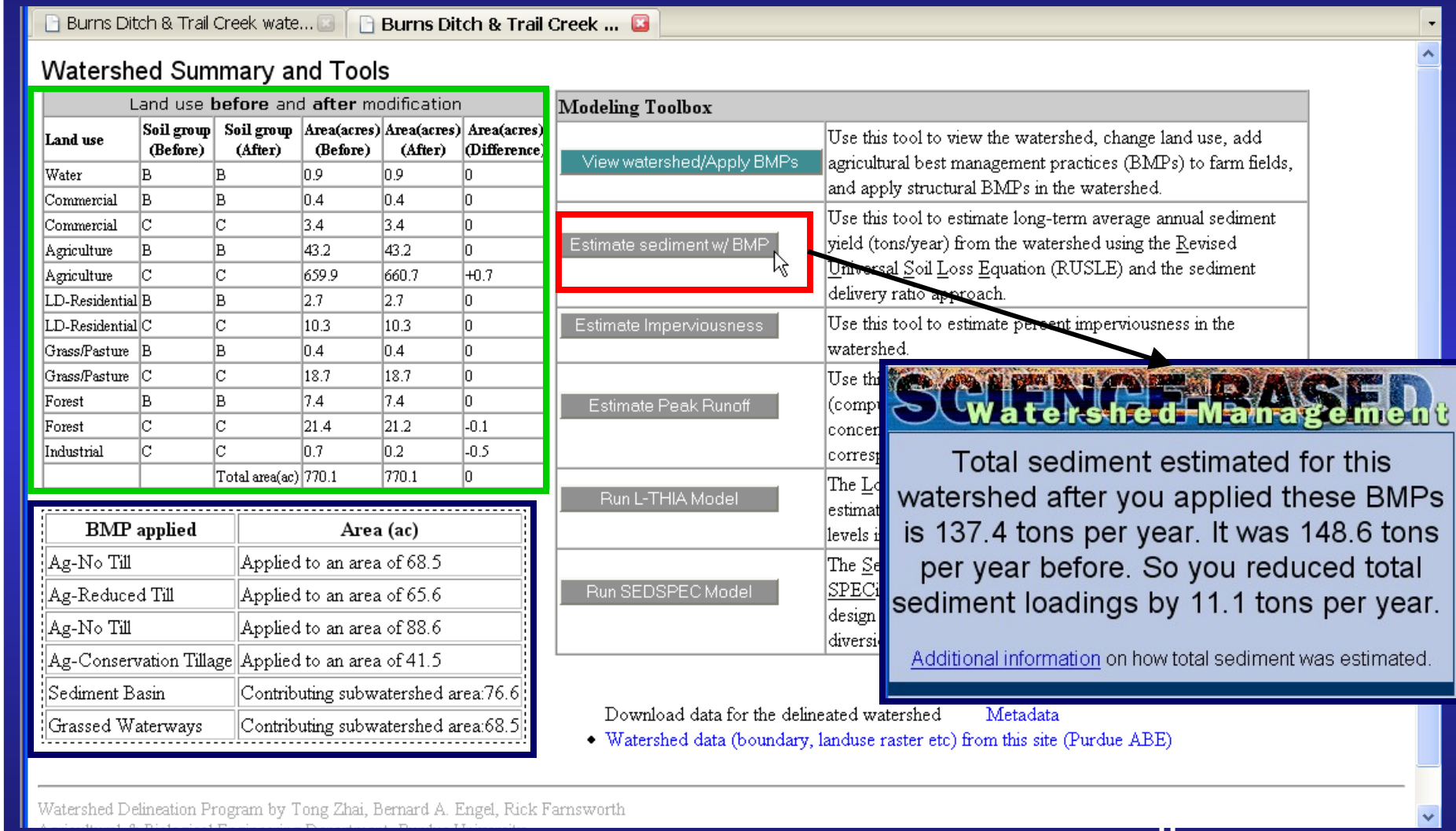
Review changes and estimate sediment after landuse changes and BMP implementation...


Burns Ditch & Trail Creek wate...
Burns Ditch & Trail Creek ...
Watershed Summary and Tools
Land use before and after modification
Land use | Soil group (Before) | Soil group (After) | Area(acres) (Before) | Area(acres) (After) | Area(acres) (Difference)
Water | B | B | 0.9 | 0.9 | 0
Commercial | B | B | 0.4 | 0.4 | 0
Commercial | C | C | 3.4 | 3.4 | 0
Agriculture | B | B | 43.2 | 43.2 | 0
Agriculture | C | C | 659.9 | 660.7 | +0.7
LD-Residential | B | B | 2.7 | 2.7 | 0
LD-Residential | C | C | 10.3 | 10.3 | 0
Grass/Pasture | B | B | 0.4 | 0.4 | 0
Grass/Pasture | C | C | 18.7 | 18.7 | 0
Forest | B | B | 7.4 | 7.4 | 0
Forest | C | C | 21.4 | 21.2 | -0.1
Industrial | C | C | 0.7 | 0.2 | -0.5
Total area(ac) 770.1 770.1 0
BMP applied | Area (ac)
Ag-No Till | Applied to an area of 68.5
Ag-Reduced Till | Applied to an area of 65.6
Ag-No Till | Applied to an area of 88.6
Ag-Conservation Tillage | Applied to an area of 41.5
Sediment Basin | Contributing subwatershed area:76.6
Grassed Waterways | Contributing subwatershed area:68.5
Modeling Toolbox
View watershed/Apply BMPs
Use this tool to view the watershed, change land use, add agricultural best management practices (BMPs) to farm fields, and apply structural BMPs in the watershed.
Estimate sediment w/ BMP
Use this tool to estimate long-term average annual sediment yield (tons/year) from the watershed using the Revised Universal Soil Loss Equation (RUSLE) and the sediment delivery ratio approach.
Estimate Imperviousness
Use this tool to estimate percent imperviousness in the watershed.
Estimate Peak Runoff
Run L-THIA Model
Run SEDSPEC Model
SCIENCE-BASED
Watershed Management
Total sediment estimated for this watershed after you applied these BMPs is 137.4 tons per year. It was 148.6 tons per year before. So you reduced total sediment loadings by 11.1 tons per year.
Additional information on how total sediment was estimated.
Download data for the delineated watershed
Metadata
Watershed data (boundary, landuse raster etc) from this site (Purdue ABE)
Watershed Delineation Program by Tong Zhai, Bernard A. Engel, Rick Farnsworth

Estimate watershed imperviousness...

Burns Ditch & Trail Creek wate... | Burns Ditch & Trail Creek ... | Burns Ditch & Trail Creek Sub-...

Watershed Summary and Tools

Land use **before** and **after** modification

Land use	Soil group (Before)	Soil group (After)	Area(acres) (Before)	Area(acres) (After)	Area(acres) (Difference)
Water	B	B	0.9	0.9	0
Commercial	B	B	0.4	0.4	0
Commercial	C	C	3.4	3.4	0
Agriculture	B	B	43.2	43.2	0
Agriculture	C	C	659.9	660.7	+0.7
LD-Residential	B	B	2.7	2.7	0
LD-Residential	C	C	10.3	10.3	0
Grass/Pasture	B	B	0.4	0.4	0
Grass/Pasture	C	C	18.7	18.7	0
Forest	B	B	7.4	7.4	0
Forest	C	C	21.4	21.2	-0.1
Industrial	C	C	0.7	0.2	-0.5
		Total area(ac)	770.1	770.1	0

BMP applied	Area (ac)
Ag-No Till	Applied to an area of 68.5
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Sediment Basin	Contributing subwatershed area:76.6
Grassed Waterways	Contributing subwatershed area:68.5

Modeling Toolbox

View watershed/Apply BMPs	Use this tool to view the watershed, change land use, add agricultural best management practices (BMPs) to farm fields, and apply structural BMPs in the watershed.
Estimate sediment w/ BMP	Use this tool to estimate long-term average annual sediment yield (tons/year) from the watershed using the Revised Universal Soil Loss Equation (RUSLE) and the sediment delivery ratio approach.
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Estimate Peak Runoff	Use this tool to estimate the peak rate of runoff, depth of runoff (computed using the SCS CN method), computed time of

Watershed Delineation Program by Tong Zhai, Bernard A. Engel, Rick Far

Impervious Area within the newly delineated watershed

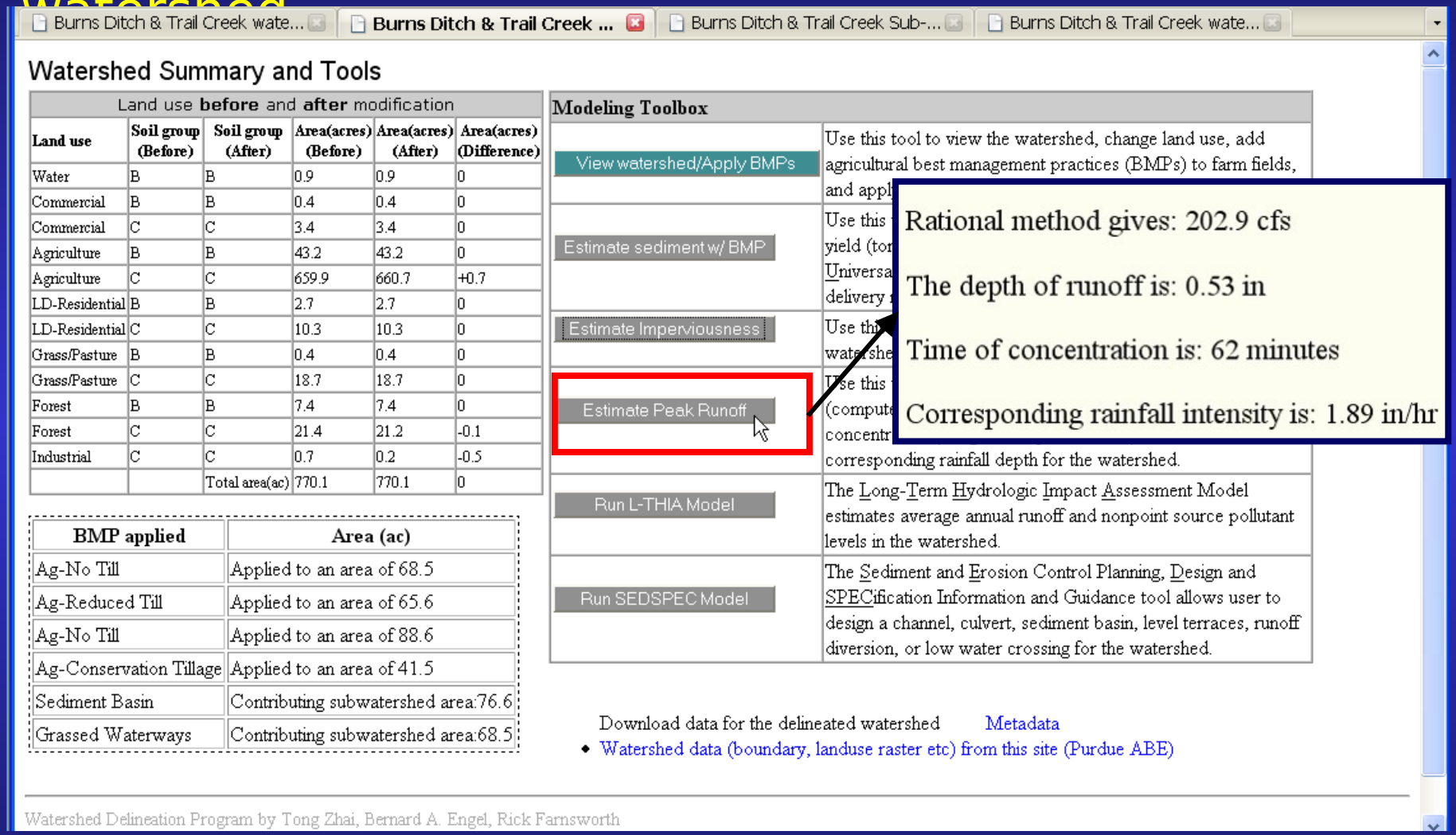
Current land use and impervious area			
Watershed Area	770.1 (acres)		
Land Use	**Soil Group**	**Area (acres)**	**Impervious Area (acres)**
Water	B	0.9	0
Commercial	B	0.4	0.2
Commercial	C	3.4	2.4
Agriculture	B	43.2	0.8
Agriculture	C	659.9	12.5
LD-Residential	B	2.7	0.4
LD-Residential	C	10.3	1.5
Grass/Pasture	B	0.4	0
Grass/Pasture	C	18.7	0.3
Forest	B	7.4	0.1
Forest	C	21.4	0.4
Industrial	C	0.7	0.3
Total Area		770.1	18.9

The impervious area in the watershed is 18.9 acres or 2.45 % of the watershed area with the current land use.

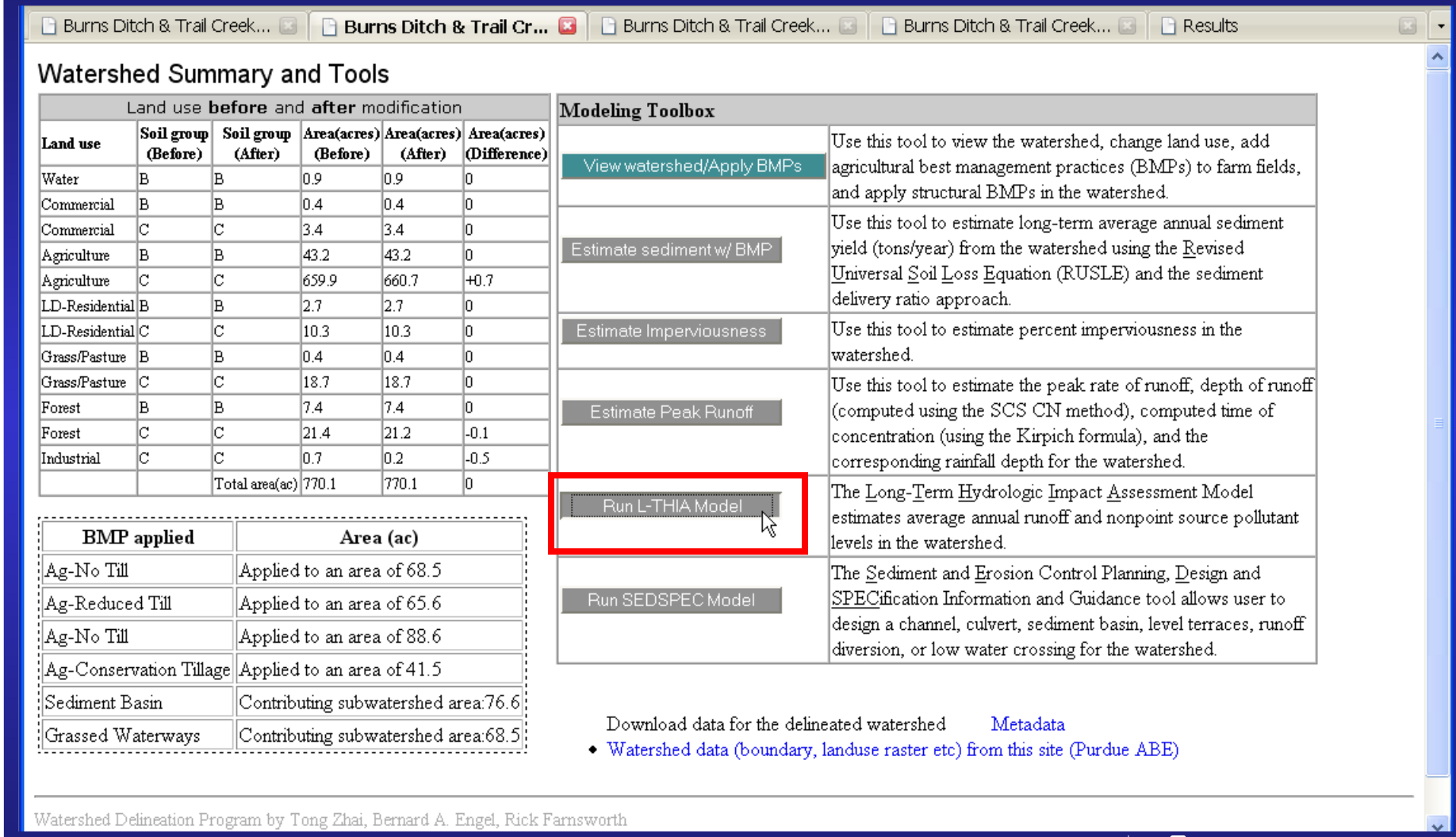
Modified land use and impervious area			
Watershed Area	770.1 (acres)		
Land Use	**Soil Group**	**Area (acres)**	**Impervious Area (acres)**
Water	B	0.9	0
Commercial	B	0.4	0.2
Commercial	C	3.4	2.4
Agriculture	B	43.2	0.8
Agriculture	C	660.7	12.5
LD-Residential	B	2.7	0.4
LD-Residential	C	10.3	1.5
Grass/Pasture	B	0.4	0
Grass/Pasture	C	18.7	0.3
Forest	B	7.4	0.1
Forest	C	21.2	0.4
Industrial	C	0.2	0.1
Total Area		770.1	18.7

The impervious area in the watershed is 18.7 acres or 2.42 % of the watershed area with the modified land use.

Calculate Peak Runoff from the watershed


Burns Ditch & Trail Creek wate...
Burns Ditch & Trail Creek ...
Burns Ditch & Trail Creek Sub-...
Burns Ditch & Trail Creek wate...
Watershed Summary and Tools
Land use before and after modification
Land use | Soil group (Before) | Soil group (After) | Area(acres) (Before) | Area(acres) (After) | Area(acres) (Difference)
Water | B | B | 0.9 | 0.9 | 0
Commercial | B | B | 0.4 | 0.4 | 0
Commercial | C | C | 3.4 | 3.4 | 0
Agriculture | B | B | 43.2 | 43.2 | 0
Agriculture | C | C | 659.9 | 660.7 | +0.7
LD-Residential | B | B | 2.7 | 2.7 | 0
LD-Residential | C | C | 10.3 | 10.3 | 0
Grass/Pasture | B | B | 0.4 | 0.4 | 0
Grass/Pasture | C | C | 18.7 | 18.7 | 0
Forest | B | B | 7.4 | 7.4 | 0
Forest | C | C | 21.4 | 21.2 | -0.1
Industrial | C | C | 0.7 | 0.2 | -0.5
Total area(ac) 770.1 770.1 0
BMP applied | Area (ac)
Ag-No Till | Applied to an area of 68.5
Ag-Reduced Till | Applied to an area of 65.6
Ag-No Till | Applied to an area of 88.6
Ag-Conservation Tillage | Applied to an area of 41.5
Sediment Basin | Contributing subwatershed area:76.6
Grassed Waterways | Contributing subwatershed area:68.5
Modeling Toolbox
View watershed/Apply BMPs
Use this tool to view the watershed, change land use, add agricultural best management practices (BMPs) to farm fields, and appl
Estimate sediment w/ BMP
Use this yield (tor Universa delivery
Estimate Imperviousness
Use thi wate she
Estimate Peak Runoff
Use this (comput concentr corresponding rainfall depth for the watershed.
Rational method gives: 202.9 cfs
The depth of runoff is: 0.53 in
Time of concentration is: 62 minutes
Corresponding rainfall intensity is: 1.89 in/hr
Run L-THIA Model
The Long-Term Hydrologic Impact Assessment Model estimates average annual runoff and nonpoint source pollutant levels in the watershed.
Run SEDSPEC Model
The Sediment and Erosion Control Planning, Design and SPECification Information and Guidance tool allows user to design a channel, culvert, sediment basin, level terraces, runoff diversion, or low water crossing for the watershed.
Download data for the delineated watershed Metadata
Watershed data (boundary, landuse raster etc) from this site (Purdue ABE)
Watershed Delineation Program by Tong Zhai, Bernard A. Engel, Rick Farnsworth

Run Long-Term Hydrologic Impact Assessment (LTHIA) to estimate runoff and NPS before and after landuse



Watershed Summary and Tools

Land use **before** and **after** modification

Land use	Soil group (Before)	Soil group (After)	Area(acres) (Before)	Area(acres) (After)	Area(acres) (Difference)
Water	B	B	0.9	0.9	0
Commercial	B	B	0.4	0.4	0
Commercial	C	C	3.4	3.4	0
Agriculture	B	B	43.2	43.2	0
Agriculture	C	C	659.9	660.7	+0.7
LD-Residential	B	B	2.7	2.7	0
LD-Residential	C	C	10.3	10.3	0
Grass/Pasture	B	B	0.4	0.4	0
Grass/Pasture	C	C	18.7	18.7	0
Forest	B	B	7.4	7.4	0
Forest	C	C	21.4	21.2	-0.1
Industrial	C	C	0.7	0.2	-0.5
		Total area(ac)	770.1	770.1	0

BMP applied	Area (ac)
Ag-No Till	Applied to an area of 68.5
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Run L-THIA Model	The Long-Term Hydrologic Impact Assessment Model estimates average annual runoff and nonpoint source pollutant levels in the watershed.
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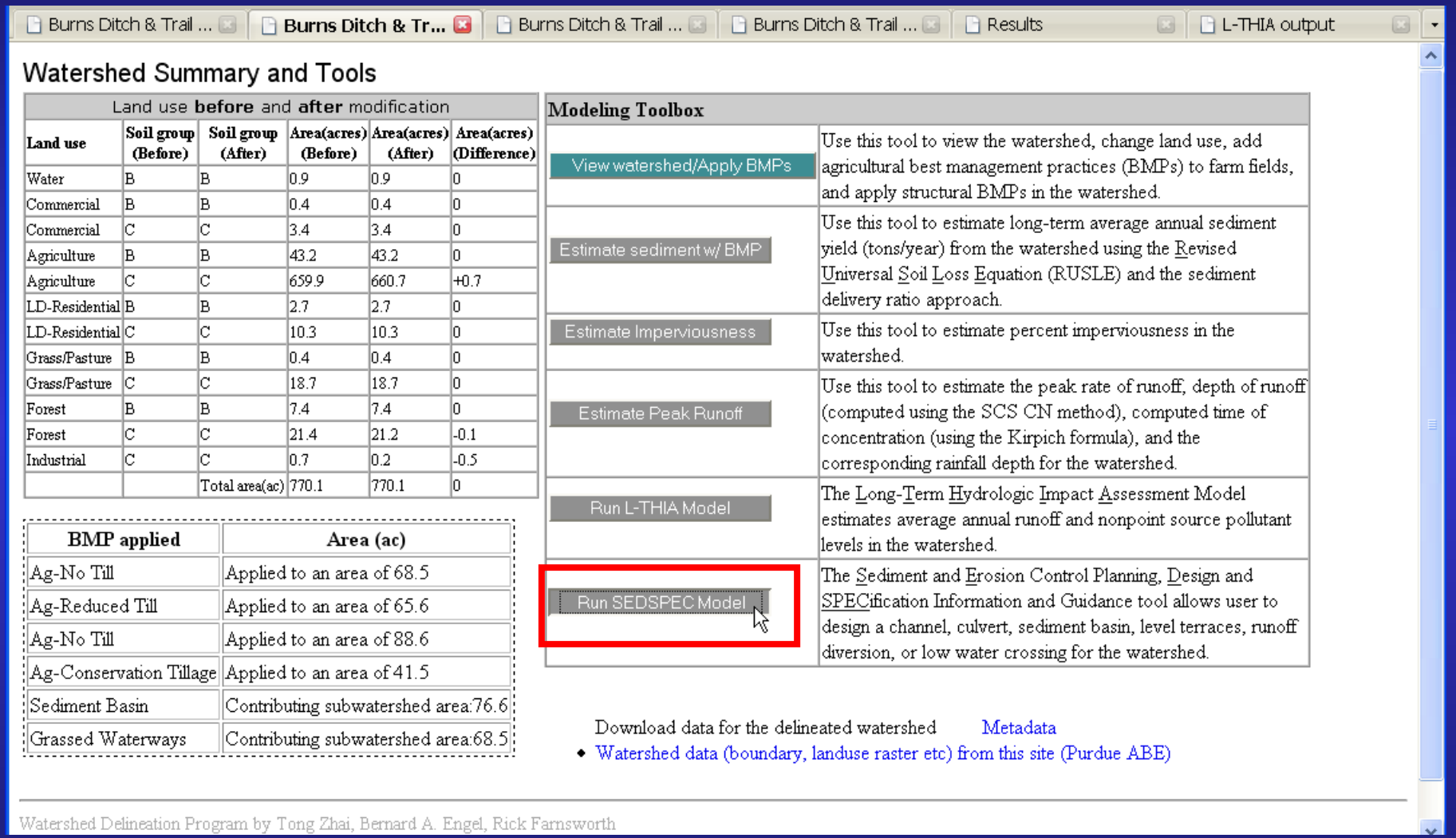
Run SEDSPEC model for structure design...



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Commercial	C	C	3.4	3.4	0
Agriculture	B	B	43.2	43.2	0
Agriculture	C	C	659.9	660.7	+0.7
LD-Residential	B	B	2.7	2.7	0
LD-Residential	C	C	10.3	10.3	0
Grass/Pasture	B	B	0.4	0.4	0
Grass/Pasture	C	C	18.7	18.7	0
Forest	B	B	7.4	7.4	0
Forest	C	C	21.4	21.2	-0.1
Industrial	C	C	0.7	0.2	-0.5
		Total area(ac)	770.1	770.1	0

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EDWARDS AQUIFER
SAN MARCOS SPRINGS
FIVE LARGE FISSURES AND MANY SMALL OPENINGS. THESE SPRINGS ARE A NATURAL DISCHARGE OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER. WATER ENTERS THIS LIMESTONE FORMATION THRU A 1505 SQUARE MILE RECHARGE ZONE WHERE THE FORMATION MEETS GROUND SURFACE IN KINNEY, UVALDE, MEDINA, BEXAR, COMAL AND HAYS COUNTIES. WATER MOVES FROM WEST TO EAST AND NORTHEAST IN THE UNDERGROUND FORMATION AND SERVES OVER ONE MILLION PERSONS IN RANCHING, IRRIGATION, MUNICIPAL AND RECREATIONAL USES.
HISTORY
DISCOVERED BY SPANISH EXPLORERS IN 1745 WHO ESTIMATED THERE WERE 200 SPRINGS. SITE OF A MISSION IN 1755-1756. AN IMPORTANT STOP ON EL CAMINO REAL, DESCRIBED BY BONNELL IN 1840 AS "THE MOST PLEASANT AND DELIGHTFUL SITUATION IN THE REPUBLIC." A STOP ON THE CHISHOLM CATTLE TRAIL FROM 1867 TO 1895.
ERECTED BY
EDWARDS UNDERGROUND WATER DISTRICT
DECEMBER 1977

QUESTIONS?

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Environmental Formulation Section, Planning Branch
US Army Corps of Engineers - Chicago District
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david.f.bucaro@usace.army.mil